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High-Technology Trade: Changed Setting for US Policy

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An Intelligence Assessment

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High-Technology Trade: Changed Setting for US Policy [redacted] 25X1

An Intelligence Assessment

This paper was prepared by [redacted] 25X1
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High-Technology Trade: Changed Setting for US Policy

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Key Judgments

Information available as of 30 November 1986 was used in this report.

Rapid technological change is fundamentally altering the basis for US foreign trade relations. Spurred by massive, rising research and development and capital investment requirements, US and foreign high-technology firms have turned increasingly to offshore production arrangements to reduce manufacturing costs and to improve access to overseas markets. As a result, conventional trade remedies could be ineffective or counterproductive:

- Restricting integrated circuits (ICs) produced in Japan almost certainly would result in greater emphasis by Japanese firms on their offshore sites in South Korea, Malaysia, and elsewhere in East Asia.
- Voluntary export restraints by a given country will become less workable as multinational companies' interests begin to diverge from those of their home-country governments.

With manufacturing operations being spread across several countries, the national identity of some high-technology products has become virtually impossible to determine. Consequently, traditional GATT disciplines and dispute-settlement procedures will be increasingly difficult to enforce on a country-to-country basis. Inclusion of investment topics in the upcoming round of multilateral trade negotiations could, however, modify GATT rules to better cover internationalized production patterns, leading to more effective remedies for handling future high-technology trade problems.

Product interdependence—such as the building-block relationships among semiconductor chips, assembled ICs, and computers—has profoundly affected high-technology trade patterns. Conventional, one-dimensional trade measures could have disastrous consequences in this multidimensional environment. For example, antidumping or countervailing duties to protect US manufacturers of ICs would adversely affect:

- US computer manufacturers relying on competitively priced ICs.
- US semiconductor firms whose offshore assembly plants produce vast quantities of ICs for shipment back to the United States.

In addition to imports and exports of physical goods, high-technology trade occurs via a complex network of interfirm sales, joint ventures, and licensing agreements. This development, together with offshore manufacturing and product interdependence, will make it extremely difficult to isolate the factors most directly affecting US security interests—dependence on foreign capabilities for defense-related efforts, erosion of US R&D leadership, and the overall US trade deficit.

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New opportunities for the United States may arise because the US market for most high-technology products is larger than all other countries' combined. Access to this market will be crucial for many foreign efforts to develop and expand high-technology capabilities—a factor that could be a major bargaining chip in future trade talks involving these products.

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Scope Note

This Intelligence Assessment is part of a broader Directorate of Intelligence analytic program that examines the internationalization of global industry. The program is designed to identify the key elements driving the internationalization process, the key sectors affected by this process, and the impact on US economic and security interests. This report assesses recent international trade patterns for five industries incorporating advanced technologies—microelectronics, computers, telecommunications equipment, aerospace, and advanced factory automation equipment—that we believe will have a significant impact on military applications as well as on overall productivity and economic performance in the future. Because of problems with the currency and specificity of many countries' trade statistics, estimates of LDC and Communist-Bloc trade in high-technology products—based on recorded exports to and imports from these countries by the United States and 19 other major trading partners [1]—were used in preparing this assessment, together with other information obtained primarily from open sources.

[1] Japan, West Germany, United Kingdom, France, Italy, Canada, Netherlands, Belgium/Luxembourg, Switzerland, Austria, Sweden, Finland, Denmark, Norway, Spain, Australia, South Korea, Hong Kong, and Singapore.

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Leading Exporting Countries in Five High-Technology Industries, 1985 (shares of total world exports)

Percent

Rank	Microelectronics	Computers	Telecommunications Equipment	Aerospace	Machine Tools and Robotics
1	**United States (23.1)**	**United States (32.3)**	Japan (24.0)	**United States (47.9)**	Japan (21.5)
2	Japan (16.6)	Japan (13.2)	Sweden (12.6)	United Kingdom (12.9)	West Germany (17.3)
3	Malaysia (10.4)	United Kingdom (8.8)	**United States (11.8)**	West Germany (10.5)	**United States (17.0)**
4	Singapore (6.1)	West Germany (8.1)	West Germany (9.5)	France (8.5)	Switzerland (8.9)
5	West Germany (5.5)	France (5.2)	Canada (8.1)	Canada (5.1)	Italy (7.4)

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High-Technology Trade: Changed Setting for US Policy

The fundamental structure of the world's high-technology manufacturing base has changed in recent years. Several high-technology industries are dominated by a relatively small number of firms that now have manufacturing facilities located around the world, that are linked by a variety of joint-venture and technology-sharing agreements, and that are increasingly participating in multinational consortiums to produce products that no single firm has the resources to manage on its own. This integration of production across national boundaries—the internationalization of high-technology industry—has blurred the national identity of products and firms. Moreover, as this process continues, equating export success with technological capabilities can be seriously misleading. At a time when the United States and its trading partners are preparing to engage in a major new round of multilateral trade negotiations, we believe it is essential to gain a clearer understanding of the forces driving high-technology trade.

Foreign Challenges to US Leadership

The United States commands a leading position in high-technology trade, accounting for a third of global exports—nearly three times the share of any other country—in five key high-technology industries [2] combined. The United States is currently the largest exporter of microelectronics, computers, and aerospace products; it ranks behind only Japan and West Germany in factory automation equipment exports, and behind Japan and Sweden in telecommunications equipment exports (table). Nevertheless, the US lead in high-technology trade has been eroding in recent years. In each of the five industries considered here, the US share of world exports declined between 1981 and 1985, primarily as a result of intensified competition by Japan and other developed countries (appendix A). Indeed, Japan's role in high-technology trade has grown significantly during this period; the Japanese export share in the five industries increased from less than 7 percent in 1981 to 11 percent in 1985.

US firms continue to dominate total world output in many high-technology industries. However, because of the internationalization of production patterns, this leadership often is not translated into equivalent export prowess for the United States as a nation. As a result, trade imbalances for various high-technology products can present widely differing challenges to US interests. In some cases—such as microelectronics imports from Japan or telecommunications equipment imports from West Germany—a worsening trade deficit can create major problems for US trade policy, paticularly when coupled with nontariff barriers sheltering the exporting countries' industries from US competition. In other cases, such as increasing net exports of semiconductors from Malaysia to the United States, a widening trade deficit does not raise the same type of concerns because it is almost entirely the result of offshore operations by US firms.

Global Trade Patterns in a New Light

Because the activities of firms employing advanced technology have become extensively integrated in offshore production arrangements and cooperative ventures, our analysis shows that high-technology trade differs from other areas of world trade in several important respects:

- Manufacturing operations are being spread across several countries as part of the internationalization process, so that the national identity of some high-technology products has become virtually impossible to determine (figure 1).

[2] The high-technology industries considered in this assessment are those involved in the production of microelectronics, computers, telecommunications equipment, aerospace, and advanced factory automation equipment.

High-Technology Trade: Pitfalls for Analysis

Certain features of high-technology industries create problems both for the measurement and for the interpretation of trade flows.

Measurement. *When the objective is to measure the flow of imports and exports embodying advanced technologies, consideration must be given to:*

- Trade in parts. *High-technology trade often takes place in the form of components or subassemblies. Unless data on parts are included along with complete products, a large portion of relevant trade will be omitted. For example, approximately two-thirds of US integrated circuit (IC) exports are accounted for by high-technology components. However, many parts categories in trade statistics contain a mixture of high- and low-technology items. The statistical category covering IC components in international trade is "electronic component parts"—which includes several products representing mature technology, such as transistors and even parts of radio vacuum tubes.*

- "Hidden" trade. *Some high-technology products are used as components in other products. For example, roughly half of Japan's IC exports are shipped as parts or subassemblies of more complex electronic products, so that the actual foreign sales of Japanese ICs are not fully measured by trade data on microelectronics alone.*

- Missing categories. *Some high-technology products do not closely resemble older products and are classified in large "miscellaneous" categories. For example, separate trade categories for industrial robots do not exist in the trade statistics of many countries with substantial robot trade. Many advanced materials, as well as products resulting from genetic engineering, do not appear in international trade figures at all—either because they are not yet being traded in appreciable quantities, or because they are still being grouped with more traditional products in international trade statistics.*

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- Definitional problems. *Some analyses have delineated high-technology industries on the basis of the relative share of spending devoted to research and development (R&D) by firms in the United States. Such classification schemes can lead to problems when applied to international trade in high technology, because the R&D intensity recorded in US industries is not the same as in other countries; industries differ widely in the criteria they use for attributing expenditures to R&D; and the industry classification systems used to record R&D and production statistics are different from those used to record trade data. As a consequence, technologically mature products such as industrial chemicals or electrical appliances make up a significant portion of "high-technology" trade as delineated by some R&D-based definitions.* 25X1

Interpretation. *The objective of analyzing high-technology trade is often to infer from trade patterns whether a country's products are competitive with those of foreign producers, or whether the sales volumes of individual firms are sufficient to support the learning effort necessary to remain competitive. In such cases, consideration must be given to:*

- Offshore production. *High-technology firms in one country often produce "offshore" in other countries to cut production and servicing costs or to circumvent trade barriers. Growing imports of products assembled in the offshore plants of home-country firms—or declining exports, because of construction of overseas plants to serve foreign markets directly—do not necessarily imply weakness of the domestic firms operating offshore plants. Such patterns may in fact be a reflection of those firms' commercial successes in world markets.*

- Multinational production sharing. *An aspect of the "globalization" phenomenon that can lead to misinterpretation of trade data is production by joint ventures or consortiums of firms of several nationalities. For example, because Airbus aircraft are delivered in Toulouse they are recorded as French exports, even though the Airbus Industrie consortium involves production by British, West German, and Spanish aerospace firms.*

- National "affiliation" of technology. *Because many high-technology firms divide their R&D activities, as well as manufacturing, among several countries, the technology belonging to such corporations has no clear national identity. For purposes of this assessment, we have identified firms' production and technology with the country of their capital affiliation, or the country of principal ownership. Thus, the semiconductor producer Mostek (originally a US company that was recently bought by a French firm) is designated as European, even though its production continues to be primarily US based.*

- Business cycles. *Demand for high-technology products may vary substantially over the business cycle; aircraft sales, for example, show strong cyclical patterns. As the leading aircraft supplier, the United States consequently registers a declining trade balance during foreign business downturns. Such "trends," however, do not necessarily reflect declining market shares or product quality.* [redacted] 25X1

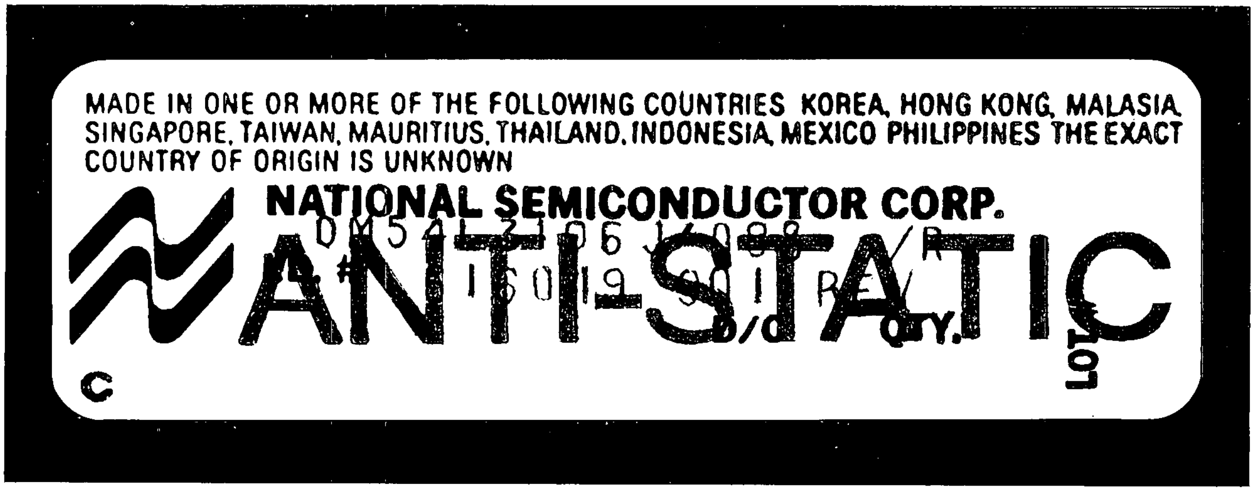


Figure 1. Shipping label for integrated circuits produced by a US firm. (Note statement that "The exact country of origin is unknown.") 25X1

- Because of the growing volume of intrafirm shipments, a country's total "affiliated" production—the combined output of domestic firms and their offshore facilities—can be as relevant an indicator as import or export levels for assessing national commercial interests in certain sectors.

- Trade in some high-technology industries now occurs via a complex network of interfirm sales, joint ventures, and technology-licensing agreements linking firms throughout the world (appendix B). With the proliferation of these linkages, imports and exports of physical goods comprise only a fraction of international transactions involving high technology.

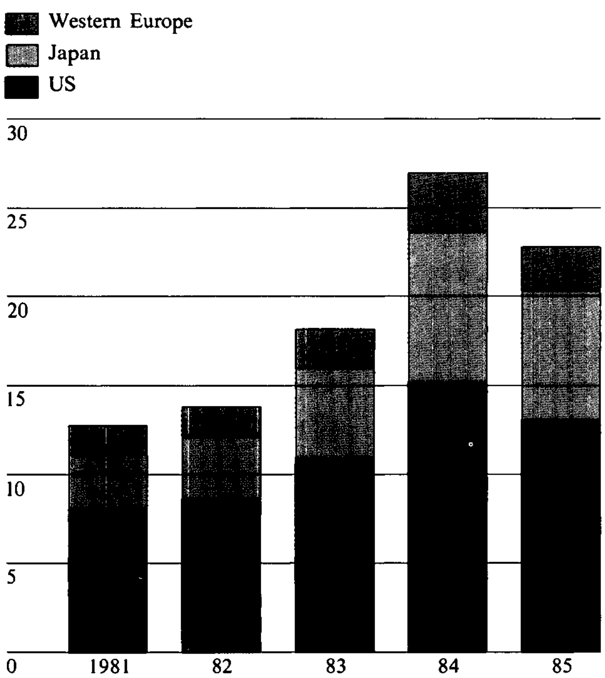
High-technology trade patterns consequently are best described in terms of a global matrix of net exports, encompassing finished equipment as well as component parts, between major regions of the world. Trade in parts and subassemblies is increasing in significance in some high-technology industries—because of offshore assembly and international production-sharing consortiums—and high-technology components sometimes follow a circuitous route through several countries en route to the end user. Such trade patterns can be missed entirely if the bilateral trade flows between any two participating countries are viewed in isolation. 25X1

Shifting Patterns of International Competition

Microelectronics. US firms lead the world in the production and export of integrated circuits and other microelectronics, yet the United States has experienced substantial microelectronics trade deficits in recent years. Between 1981 and 1985 the US share of total microelectronics exports fell from almost 26 percent to just over 23 percent (appendix A). The eroding US trade position was partly caused by challenges from increasingly capable Japanese competitors, as Japan's net exports of microelectronics soared from $955 million in 1981 to $2.7 billion in 1985. Nonetheless, we estimate that total US semiconductor production—including both domestic and offshore facilities of US firms (figure 2)—continues to exceed that of Japanese and European microelectronics firms combined. 25X1

Figure 2
Estimated Worldwide Production of Integrated Circuits by US, Japanese, and West European Firms, 1981-85[a]

Billion US $



[a] Encompasses domestic as well as offshore production of integrated circuits by locally owned firms and their subsidiaries in other countries. Production estimates include sales plus estimated market value of intracompany transfers.

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Because of internationalization of the industry, the economic interests and technical capabilities of the United States and other microelectronics-producing countries cannot be identified solely in terms of bilateral trade flows:

- Microelectronics *products* are being manufactured globally, now that distinct stages of production can be spread among several different countries to exploit local cost advantages or to avoid trade barriers.
- Principal microelectronics-producing *companies* now operate throughout the world, manufacturing in all major industrial-country markets as well as in Southeast Asia (figure 3). Thus, the nationality of some microelectronics-producing firms can be as indistinct as that of their products. [redacted] 25X1

When shipments among all major world regions are taken into account, a massive two-way exchange between the United States and East Asia—primarily the Southeast Asian countries—can be seen to dominate the global network of microelectronics trade (figure 4). However, Southeast Asian production of integrated circuits (ICs) consists almost entirely of assembling components that are shipped from the United States. Using data on US foreign direct investments, we estimate that 90 percent of US microelectronics imports from East Asian countries, other than Japan, are shipments to US parent firms from their foreign subsidiaries. Since overseas plants add value to the component parts, the value of the returning trade flow is necessarily greater than the outward flow. This contributes to US trade deficits, as conventionally measured, in microelectronics and other industries characterized by extensive offshore assembly. [redacted] offshore 25X1 assembly is a small, though growing, part of the Japanese microelectronics industry as well. [redacted] 25X1

The relative strengths of the United States, Japan, and Western Europe in design and production will continue to be reflected only partially in their respective microelectronics trade balances, in our estimation, because of two characteristic features of the industry: 25X1

- The existence of "commodity" or off-the-shelf ICs having widely accepted designs—and, thus, relatively large sales volumes—as distinguished from "custom" ICs that are designed to meet end users' unique specifications.

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Figure 3
International Production and Trade in Microelectronics: The Key Players

Affiliation	Rank[a]	Company	Manufacturing location: United States	European Community	Japan	Other East Asia
United States	1	IBM	●	●	●	
	2	Texas Instruments	●	●	●	●
	4	Motorola	●	●	●	●
	5	AT&T	●			
	7	Intel	●		●	●
	10	National Semiconductor	●	●		●
	12	AMD	●	●		●
	18	Hewlett-Packard	●			●
	20	Harris	●	●[b]		●
	22	RCA	●			●
	23	Analog Devices	●	●	●	
Western Europe	11	Philips/Signetics (Neth.)	●	●		●
	15	Fairchild (France)	●	●	●	●
	17	Thomson/Mostek (France)	●	●		●
	21	SCS-Ates (Italy)	●	●		●
	24	Siemens (West Germany)		●		●
Japan	3	NEC	●	●	●	●
	6	Hitachi	●	●	●	●
	8	Toshiba	●	●	●	●
	9	Fujitsu	●	●	●	
	13	Matsushita	●		●	●
	14	Mitsubishi	●		●	
	16	Sanyo			●	●
	19	Oki	●		●	
	25	Sharp			●	

[a] Firms are ranked internationally in approximate order of total sales (including internal transfers) of integrated circuits in 1985.
[b] Joint venture only.

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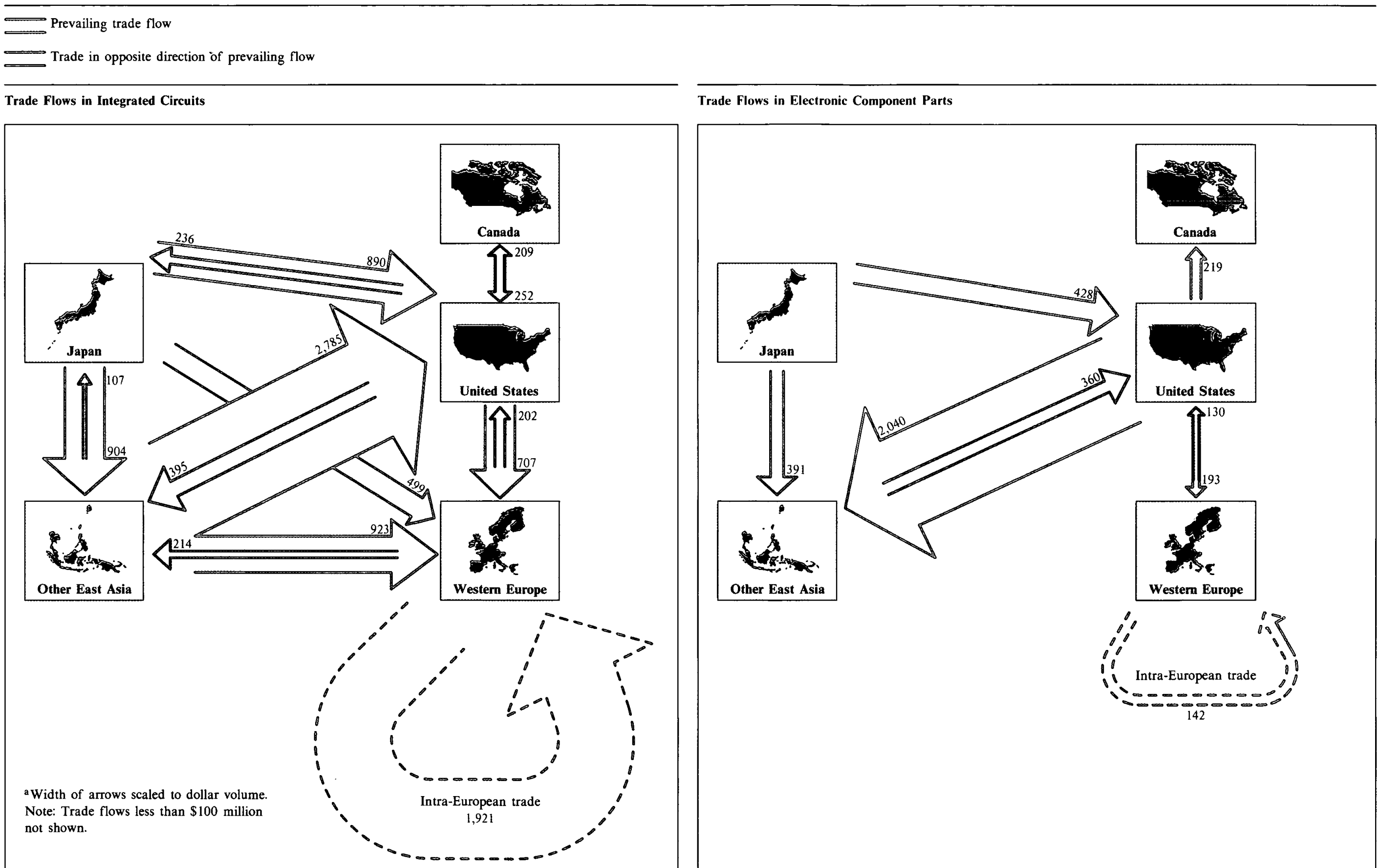
Figure 4
World Trade Flows in Microelectronics, 1985[a]

Million US $



[a]Width of arrows scaled to dollar volume.
Note: Trade flows less than $100 million not shown.

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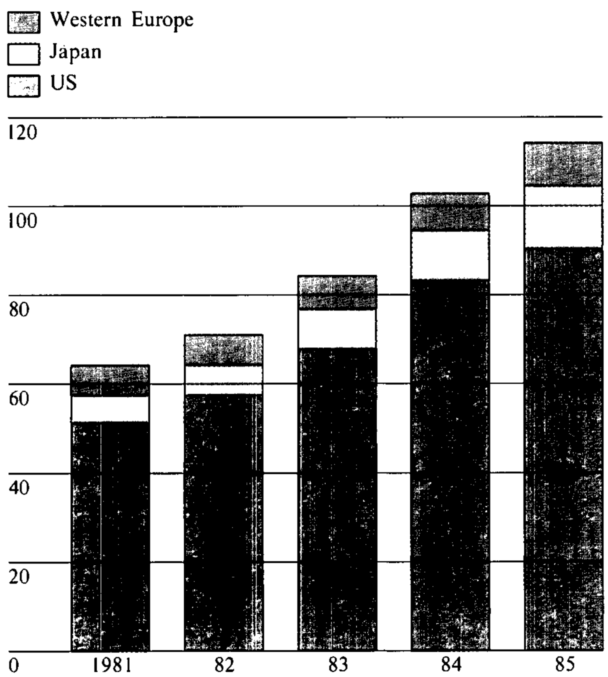
Figure 5
Estimated Worldwide Production of Computers by Leading US, Japanese, and West European Firms, 1981-85[a]

Billion US $



[a] Estimates based on total data-processing revenues of 50 leading computer firms. Total revenues include sales of mainframe computers, minicomputers, microcomputers, data communication equipment, peripherals, software, maintenance, and services.

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- Differences among the types of IC applications prevailing in the major industrial countries—with consumer electronics accounting for nearly half of IC sales in Japan, while most ICs sold in the United States are used in data-processing and other (government, military, and industry-specific) applications. [redacted]

Japan's strong capabilities in manufacturing have enabled Japanese firms to progressively dominate world markets for commodity ICs. Because international trade in microelectronics (other than the parent-subsidiary shipments resulting from offshore assembly) is largely comprised of commodity ICs, the US trade position in microelectronics has worsened relative to Japan's during the past five years, even though US firms have continued to lead the world in overall IC production. Custom ICs, on the other hand, generally require close coordination (and proximity) between the manufacturer and end user, especially in design, and as a result are traded less internationally than commodity ICs. [redacted] 25X1
US firms have maintained a relatively strong export position in custom ICs used in the computer industry, in which US producers are dominant. In contrast, expertise developed by serving producers of consumer electronics, in which Japanese firms are strongest, appears to have given Japanese microelectronics producers a commanding export position in custom chips for consumer electronics. In our judgment, the fact that Western Europe accounts for 22 percent of world microelectronics exports is not a valid indication of European firms' strength relative to US or Japanese producers because production by US-owned subsidiaries located in Europe, together with IC imports from the United States, account for nearly half of total West European microelectronics consumption. [redacted] 25X1

Computers. Notwithstanding the overwhelming dominance of world computer production by US-affiliated firms (figure 5) and the role of the United States as the world's leading exporter of computer equipment, 25X1 the US trade surplus in this sector has shrunk in recent years as the growing US market absorbed more imports, especially of computer parts. Although IBM and other US manufacturers command more than 80 percent of world sales of personal and minicomputers, their products now extensively incorporate foreign-made components and subassemblies (figure 6), primarily to reduce costs. [redacted] 25X1
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Figure 6
Globalization of Computer Production: Foreign-Made Components in the IBM Personal Computer

Percent ($)

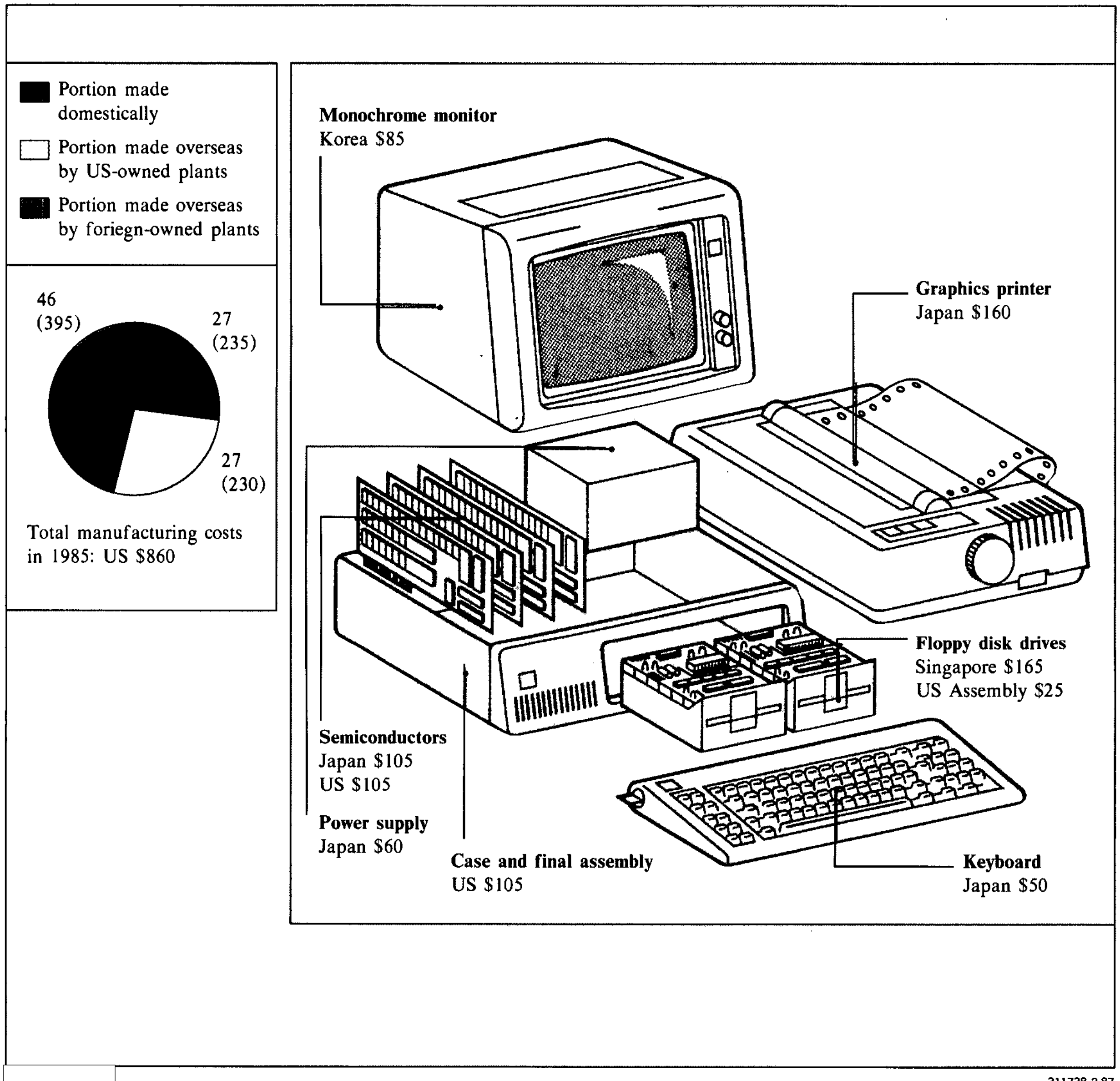

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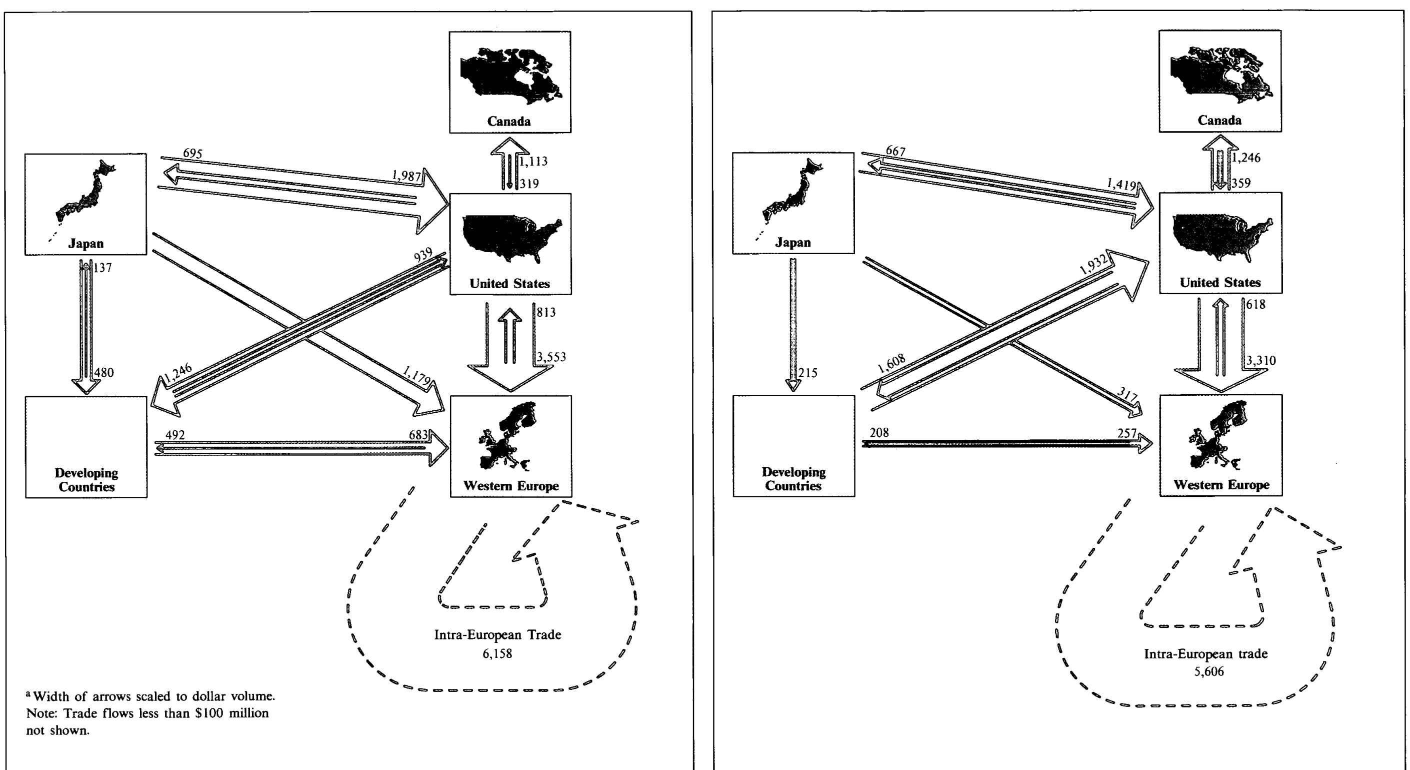
Figure 7
World Trade Flows in Computers and Parts, 1985[a]

Million US $

Prevailing trade flow

Trade in opposite direction of prevailing flow

Trade Flows in Computer Equipment / **Trade Flows in Computer Parts**



[a] Width of arrows scaled to dollar volume.
Note: Trade flows less than $100 million not shown.

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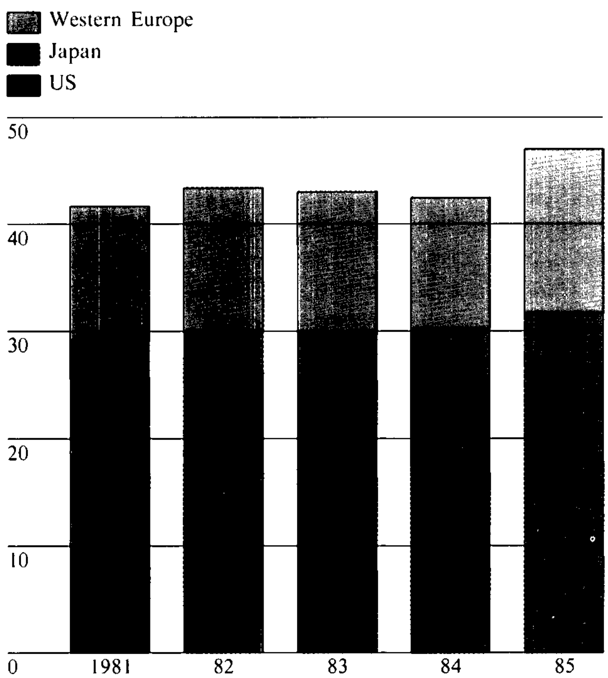
Figure 8
Estimated Worldwide Production of Telecommunications Equipment by US, Japanese, and West European Firms, 1981-85 [a]

Billion US $



[a]Production estimates based on total domestic and foreign sales of 25 leading firms and their subsidiaries in other countries. Totals for Western Europe include firms based in West Germany, France, UK, Italy, and Sweden.

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Another factor having adverse effects on the US trade balance in computers is the US firms' growing practice of selling automatic data-processing (ADP) equipment in foreign markets that is manufactured by overseas subsidiaries rather than exported from the United States. On the basis of company reports, we estimate that roughly one-third of the assets of leading US mainframe companies are located overseas, principally in Western Europe and Japan. This pattern is prompted by the need to adapt products to local markets as well as by efforts to avoid foreign import barriers; it has had the effect not only of reducing the US trade surplus in computers but of boosting other countries' export shares as well. For example, we estimate on the basis of data-processing and export data that approximately 40 percent of Japan's computer exports are accounted for by IBM and other US firms operating in Japan. 25X1

About half of world trade in computers consists of components and parts, and is carried out largely through a network of linkages among US, Japanese, and West European computer firms. (For a partial depiction of these linkages, see appendix B.) Only some of the linkages entail actual shipment of complete computer equipment; others involve technology licensing and capital participation. Japanese firms, for example, sell mainframes abroad almost entirely through affiliates in other countries. This offers Japanese computer firms a way of selling relatively small volumes in other markets—they account for about 5 percent of the US mainframe market and even less in Western Europe—without incurring the cost of establishing local service networks. 25X1

Interregional patterns of trade in computer equipment and parts (figure 7) have shifted considerably in the past five years, contributing to further erosion of the US trade position in this sector. In 1981 the United States was a net exporter of ADP equipment and parts to all regions, including Japan. By 1985 the United States had become a net importer from Japan and the East Asian LDCs, largely reflecting purchases of peripherals and components associated with personal computers. These products are now being exported in substantial volumes by Japan and, increasingly, the East Asian NICs. Western Europe's trade deficit in computers (excluding intra-European trade) deteriorated from $4.1 billion in 1981 to $6.8 billion in 1985. Nearly $12 billion in ADP equipment was traded within Western Europe in 1985, but, according to our estimates, well over half of West European sales are by US data-processing firms operating there. 25X1

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Internationalization in the Telecommunications Industry: Selected Linkages Among Major Producers

A major factor in international markets for high-technology telecommunications switching equipment is the growing number of financial, research, and marketing linkages among major producers in the United States, Western Europe, and Japan. 25X1

The world's 12 leading telecommunications equipment suppliers, ranked in order of their total sales in 1985, are:

Rank	Firm	Nationality	Sales Share *(percent)*
1	AT&T	United States	27.1
2	ITT	United States	11.1
3	Siemens	West Germany	10.7
4	Northern Telecom	Canada	9.3
5	Ericsson	Sweden	7.1
6	IBM (and Rolm)	United States	7.1
7	NEC	Japan	6.4
8	Alcatel Thomson	France	6.0
9	GTE	United States	5.6
10	Philips	Netherlands	3.8
11	GEC	United Kingdom	3.1
12	Fujitsu	Japan	2.7

A variety of linkages are currently in effect or under discussion among these leading firms. For example:

- AT&T *and* Phillips *established a joint venture to sell telecommunications equipment in Western Europe. The joint venture,* APT, *is attempting to acquire* CGCT, *a small French producer.*
- CGE, *a holding company for* Alcatel Thomson *formed by the merger of the leading French telecommunications firms, is attempting to form a joint venture with* ITT. *The venture is to include all of ITT's telecommunications equipment production and to be dominated by CGE.*
- GEC *attempted to purchase the British firm* Plessey, *with which it codeveloped "System X." Purchase was opposed by Plessey and blocked by the UK monopolies commission.*
- GTE *and* Siemens *have long been discussing a joint venture. Talks recently ended without an agreement on switching equipment.*
- Alcatel Thomson, Italtel, Siemens, *and* Plessey *have agreed on joint research plans for computerized office systems.* 25X1

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Telecommunications Equipment. Although US-affiliated firms dominate the production of telecommunications equipment internationally (figure 8), the United States ranks behind Japan and Sweden in exports of this equipment. Much of the production of telecommunications equipment by US firms—especially ITT, the world's second-ranking equipment producer after AT&T—takes place in overseas facilities for sale in host-country markets.[3] Since 1982 the United States has experienced a steadily deteriorating trade balance in telecommunications equipment, with the deficit reaching $1.2 billion in 1985.[4] As shown in appendix A, Western Europe has retained a strong position in telecommunications equipment trade over the past five years while Japan, the world's leading exporter in the sector, now accounts for nearly a quarter of world telecommunications equipment exports. 25X1

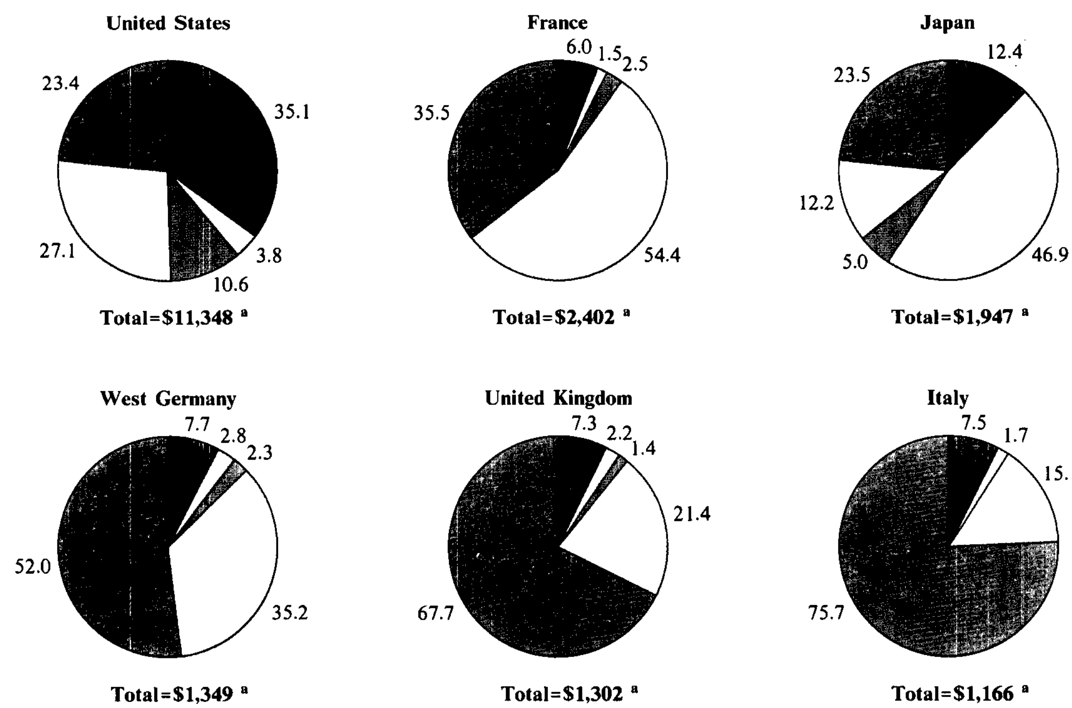
[3] The recently announced accord between ITT and CGE of France apparently will result in significant reduction or termination of ITT's role as an autonomous equipment producer. We estimate that such a change could reduce the share of world telecommunications equipment sales attributed to US firms from 60 percent to just under 50 percent.

[4] This includes some products, such as telephone handsets, that represent standardized or mature technologies. In 1985, 41 percent of US imports (but only 4 percent of exports) of telecommunications equipment were telephone instruments. The US trade balance in high-technology telecommunications switching equipment also declined, from a small surplus in 1980 to a deficit of $150 million in 1985. 25X1

Figure 9
Composition of Telecommunications Equipment Markets in the Major Industrial Countries, 1985

Percent

- Data-communications equipment
- Facsimile-terminal equipment
- Fiber-optic communications systems
- Private telephone and data switching
- Public telephone and data switching



[a] Million US $

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International telecommunications trade is significantly affected by the wide variation in the composition of markets in the major industrialized countries (figure 9). Although about one-third of sales in the US market is now comprised of data-communications equipment, these products generally make up less than a tenth of the telecommunications equipment sold in the other major industrial countries. In contrast, the largest segment of Japan's telecommunications market is facsimile-terminal equipment, which increasingly is being used in transmission of Japanese-language materials. Experience gained in serving local markets is likely to help producers of these various products to expand sales in other countries in the coming years.

The percentage of world telecommunications equipment production that is exported is lower than that of most high-technology products. Of an estimated $60 billion in telecommunications equipment produced in the developed countries in 1984, only 5 percent was traded with other developed countries—and two-thirds of that trade consisted of exports to the United States. As many developing countries are in the process of building national networks, the LDCs as a group play a significant role as importers of telecommunications equipment.

We believe that the relatively low volume of international trade in telecommunications equipment results primarily from nontariff barriers, such as preferential procurement by public telecommunications utilities and manipulation of standards to favor local producers in the developed countries. Through their regulatory role, all governments exert substantial influence on their communications systems. In major countries where the government has controlled postal, telephone, and telegraph authorities (PTTs)—especially Japan, West Germany, and France—imports have comprised an extremely small portion of telecommunications equipment sales. As a result, national telecommunications equipment markets in much of Western Europe are highly compartmentalized, and local suppliers tend to rely heavily on protected orders and subsidies from their national PTTs. In contrast, we estimate that imports account for nearly 18 percent of telecommunications equipment sales in the United States and more than 20 percent in the United Kingdom. Technical differences between national communications systems are also an impediment to trade—but not necessarily an insurmountable one, as demonstrated by growing equipment sales in the relatively open US and British markets by manufacturers from other countries.

Because of widespread obstacles to trade, US telecommunications firms have sought ways other than direct exports to market their products internationally. The performance of US-owned ITT, the largest seller of telecommunications equipment in Western Europe in past years, indicates that telecommunications firms can obtain significant sales in other countries through local manufacturing facilities. Joint ventures play a similar role, as illustrated by the arrangement formed by AT&T and Philips to sell switching equipment modified to fit European standards,[5] and by Ericsson's sales in the United Kingdom.[6] As a result of these trends, the structure of the telecommunications equipment sector may be evolving in directions similar to the computer industry—with a limited number of large and increasingly dominant firms joining together (appendix B)—but with a much smaller volume of international trade being generated. 25X1

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Aerospace. The United States continues to hold a commanding position in international aerospace trade. However, changes under way in the industry—especially those spawned by the growing number of multinational consortiums—are increasing the role of foreign countries in the production of aircraft and jet engines (figure 10). We expect these trends to continue, leading to somewhat smaller US shares of total exports in the coming years. Moreover, while we believe relative US strengths in aerospace design and production are unlikely to diminish in the foreseeable future, conventional interpretations of international export shares may suggest the opposite. 25X1

Most aerospace firms—reflecting their dual roles as commercial producers and defense contractors—can be clearly identified with a single country, but the national identity of their nonmilitary production is often less distinct. An example is the Airbus A-320. Most of the work on the 150-passenger narrow-body design is shared among the four countries participating in the Airbus Industrie consortium (France, West Germany, the United Kingdom, and Spain). Purchasers of the A-320 are given a choice of engines that also involve multinational production: the V-2500 (produced jointly by US, British, Japanese, West

25X1

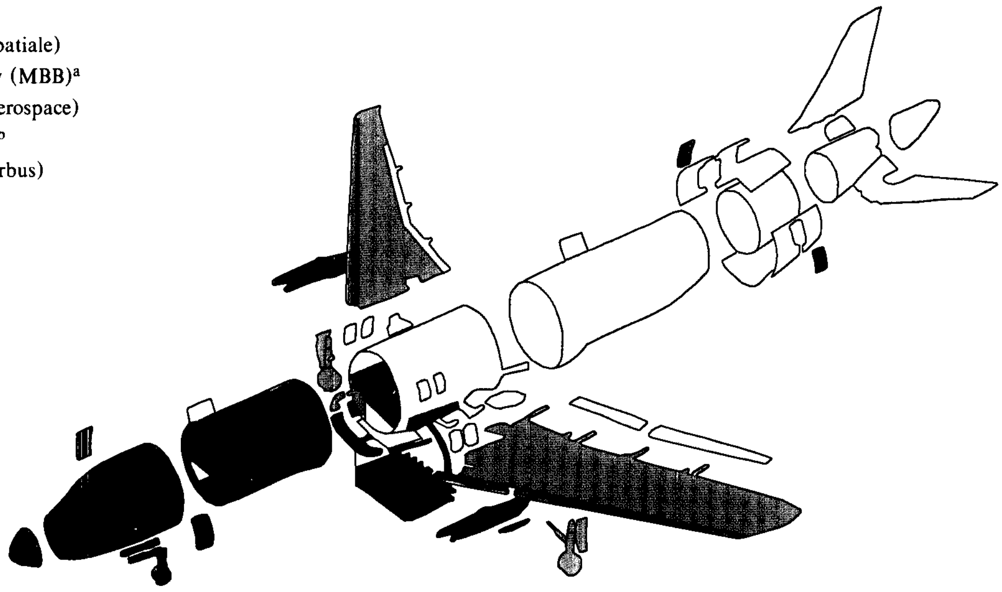
[5] The principal customer of the AT&T-Philips venture is the Dutch public telephone network, and much of the joint-venture's production, including final assembly, takes place in the Netherlands. 25X1

[6] Ericsson of Sweden has been awarded a contract for about 15 percent of recently privatized British Telecom's switching requirements, in competition with BT's traditional domestic suppliers. The switches are to be produced in the United Kingdom through a joint venture between Ericsson and Britain's Thorn-EMI. 25X1

Figure 10
The Role of National Producers in Multinational Projects: Production Sharing in the Aerospace Industry

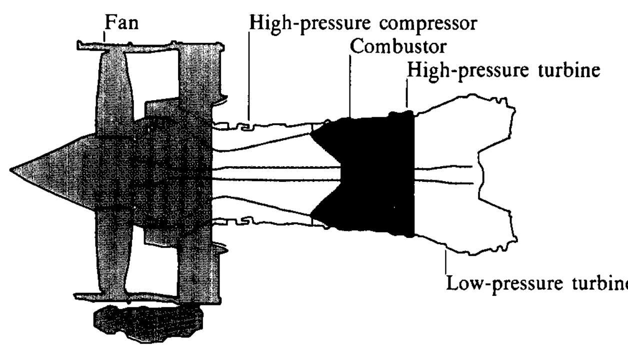
Airbus A-320

- France (Aérospatiale)
- West Germany (MBB)[a]
- UK (British Aerospace)
- Spain (CASA)[b]
- Belgium (Belairbus)



International Aero Engines V-2500

- US (Pratt & Whitney)
- UK (Rolls-Royce)
- Japan (JAEC)[c]
- West Germany (MTU)[d]
- Italy (Fiat)



[a] Messerschmitt-Bolkow-Blohm
[b] Construcciones Aeronauticas SA
[c] Japanese Aero Engine Company
[d] Motoren- und Turbinen-Union

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German, and Italian firms), or the CFM56 (produced by General Electric and France's SNECMA). Multinational consortiums are not unique to European aerospace production; Boeing's 767 and its planned 150-seat 7J7 airliner involve foreign—including substantial Japanese—participation on a risk-sharing basis. [redacted]

We believe the internationalization of commercial aircraft manufacturing will accelerate in the 1990s, driven by two important characteristics of the industry:

- *Massive initial costs.* These costs are incurred in the development and certification of new models as well as the research underpinning new technology. Industry experts put the cost of developing a new jet engine at about $1.5 billion; the development cost of an all-new aircraft is more than $2.5 billion. With costs of this magnitude, sales of 600 to 700 aircraft in the first 10 years after deliveries start are needed if a program is to be profitable. By spreading development costs and risks among participants, however, consortiums can substantially reduce the burden borne by each individual firm.

- *Government support.* Intended to acquire or develop advanced aerospace and related technology, this support takes the form of preferential purchasing by national airlines as well as direct support. Through participation in multinational consortiums, aerospace firms gain access to markets and subsidies in several countries.

The forces that encourage formation of production-sharing consortiums also lead to extensive trade, primarily in parts, among aerospace firms. Industry analysts estimate that foreign components accounted for roughly 7 percent of the content of US civil air transport production in the 1980-84 period. In contrast, the US content of Airbus aircraft is between 20 and 30 percent, depending on the model and engine chosen by purchasers. [redacted]

The volume of trade in aerospace products is being increased by the way in which consortiums, such as Airbus Industrie, divide production among participating firms of several nationalities—with components and subassemblies produced in one country often shipped to an assembly point in another country. As a result of these transactions, West European countries account for a large share of world aerospace exports but, when intra-European trade is excluded, have a fairly small overall aerospace trade surplus (appendix A). They also generate a larger volume of shipments of aircraft and parts within Western Europe than among any other world regions (figure 11). The principal trade flow in jet engines and parts, however, is a roughly two-way exchange between Western Europe and the United States. Our analysis shows that this pattern reflects the successful coproduction of the CFM56 engine by General Electric and France's SNECMA—with production of components as well as final assembly divided equally between the partners. [redacted] 25X1

As in several other areas of high technology, various countries' trade performance in aerospace is not a clear indicator of their underlying technical or commercial capabilities. Thus, a large export share or level of production in aerospace may correspond with capabilities only in a limited range of components—without implying an ability to successfully develop and manufacture entire aircraft or engines. West Germany, for example, is the world's third-ranking aerospace exporter (appendix A) but nevertheless has a trade deficit in aerospace that is greater than any other major industrialized country's except Japan's. [redacted] 25X1

Advanced Factory Automation Equipment. The US trade balance in machine tools, special machines, and robotics [7] significantly worsened in recent years, moving from a $389 million surplus in 1981 to a $1.1 billion deficit in 1985 (appendix A). Although trade data provide an approximation of overall international competitive developments involving advanced factory automation equipment,[8] they are less useful for examining trends in specific products. Some non-high-technology equipment, for example, is included in

[7] As used here and in appendix A, trade data on "machine tools and robotics" include metalworking machine tools as well as machines that are used in factory automation in several industries (that is, electric welding machines and special-function machines designed for unique manufacturing operations). [redacted] 25X1

[8] Advanced factory automation equipment includes some machine tools (non-hand-held metal-cutting, shaping, or forming machines), robots (reprogrammable manipulators), and flexible manufacturing systems (computer-integrated systems of machine tools, robots, and other factory equipment). [redacted] 25X1

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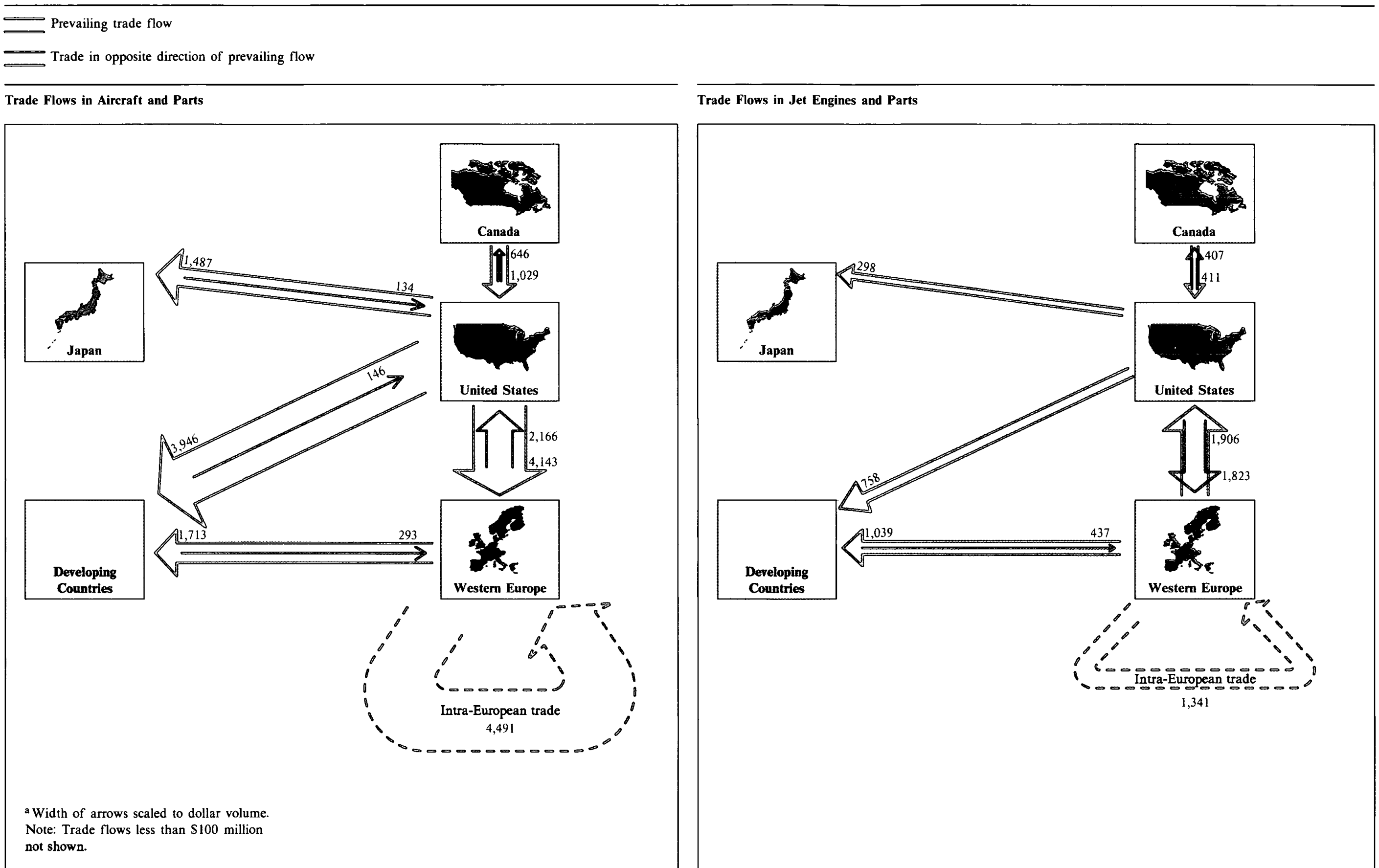
Figure 11
World Trade Flows in Aerospace, 1985[a]

Million US $



[a] Width of arrows scaled to dollar volume.
Note: Trade flows less than $100 million not shown.

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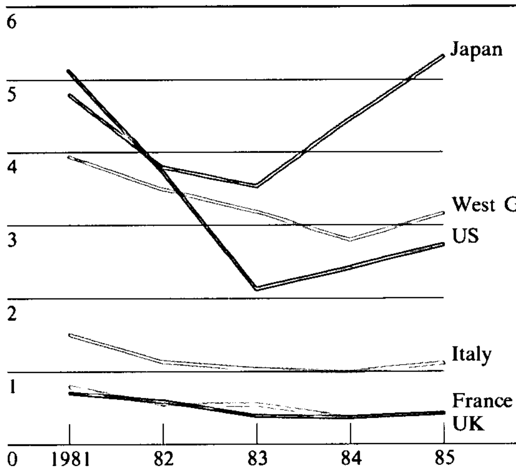
Figure 12
Machine Tools and Robotics in the US, Japan, and Western Europe

Note scale change

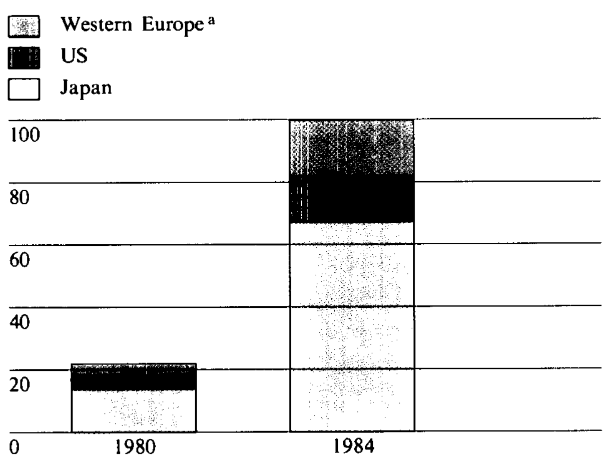
Production of Machine Tools in the US, Japan, and Western Europe, 1981-85

Billion US $



Industrial Robots in Operation in the US, Japan, and Western Europe, 1980 and 1984

Thousands



Note: More encompassing criteria are applied in designating equipment as "robots" in Japan than in the US or Western Europe. The Japanese share of total robots in operation, as shown here, is consequently overstated to some extent.

[a] Includes West Germany, France, United Kingdom, Italy, and Sweden.

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trade categories covering the advanced segment of the industry, while some relevant products—such as electronics for factory automation and shipments that do not take an obviously "robot" form—are missed because they are included in other industry categories. 25X1

Conventionally measured trade patterns provide an incomplete picture of the international transactions in advanced factory automation equipment that are now taking place among the many specialized producers in the major industrialized countries. These producers are connected globally through a network of interfirm sales, joint ventures, and technology licensing agreements, with extensive cross trading of both complete units and component parts taking place. Of the numerous connections that have linked major US, Japanese, and West European robotics firms (appendix B), only the direct marketing linkages entail cross-border shipments that are ultimately registered in national trade statistics. 25X1

International linkages among producers of factory automation equipment are increasing in response to two factors in particular:

- The fragmentation of the industry into many small, highly specialized market niches—with relatively low sales volumes but high R&D requirements—that tends to limit the number of firms that are able to operate in each segment worldwide.

- The importance of proximity to end users in supplying equipment—often tailored to fit their unique specifications—as well as the requirement for local servicing.

Market fragmentation and proximity to purchasers, coupled with the highly cyclical nature of the market for advanced factory automation equipment, have contributed to Japan's recent strength in overall machine tool production, as well as to the more extensive use of industrial robots in Japan than in Western Europe or the United States (figure 12). The Japanese manufacturing sector grew rapidly during the late 1970s and has fallen relatively little in the 1980s,

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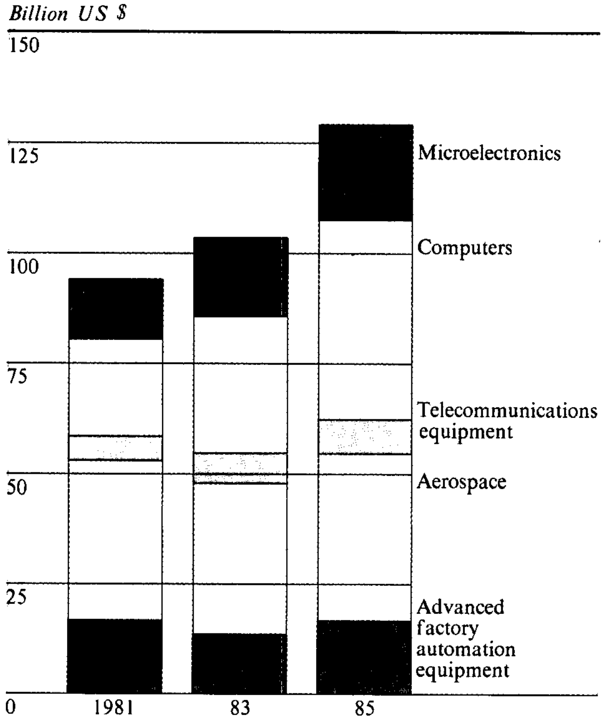
Figure 13
Growth of World Trade in Five Critical High-Technology Industries, 1981-85



Countries Accounting for at Least 1.5 Percent of Total Exports of Five High-Technology Industries

1981	1985
United States	United States
Japan	Japan
West Germany	West Germany
United Kingdom	United Kingdom
France	France
Italy	Italy
Canada	Canada
Netherlands	Netherlands
Switzerland	Switzerland
Sweden	Sweden
Singapore	Singapore
Malaysia	Malaysia
	South Korea
	Taiwan
	Hong Kong

[redacted]

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while manufacturing in the other industrialized countries experienced cyclical declines during these years. The impact of Japanese demand has been particularly strong in the rapidly growing robotics segment of the factory automation equipment industry, and Japanese robot vendors are using the expertise developed in Japan to serve export markets. We estimate that roughly a fifth of Japan's $1.6 billion in robot production is exported, about two-thirds of which goes to the United States. [redacted] 25X1

Exports of advanced factory automation equipment are being carried out primarily through sales to "integrators" in consumer countries rather than by direct sales to end users. The integrators are often robot or machine tool manufacturers themselves and tailor factory automation systems to meet users' specific requirements. [redacted] 25X1
the largest seller of robots in the United States—GMF Robotics, a partnership between General Motors and Fanuc, a leading Japanese producer of machine tools and robots—imports most of its hardware from Fanuc's plants in Japan while the applications expertise is provided by GM. [redacted] 25X1

Outlook and Implications

More Players, Higher Stakes. We believe that the number of national and corporate players involved in high-technology trade will continue to grow, further complicating the formulation and implementation of US policy. World exports in the five high-technology industries considered here have expanded at an average annual rate of more than 8 percent during the past five years, with firms from more countries taking an active part in this trade (figure 13). At the same time, the linkages among these firms—for R&D, production, and marketing purposes—have become significantly more complex. We believe that this process of internationalization will continue and may well accelerate in coming years. [redacted] 25X1

The United States has a major and growing economic and security stake in high-technology trade. [redacted] 25X1
[redacted] high-technology industries provide roughly one-third of employment and nearly 25X1

25X1

40 percent of value added in the US manufacturing sector. In addition, these industries have become exceptionally dependent upon world markets. We estimate that export sales account for approximately 35 percent of output in US high-technology industries, compared with only 15 percent of output in other US manufacturing industries. Many foreign governments and firms also appear to be setting their sights on world markets for high-technology products, in light of the strong export growth rates that have been registered recently in several of these industries. In Japan, West Germany, France, and the United Kingdom, as well as in the United States, exports of the five key high-technology industries have been increasing as a proportion of total exports between 1981 and 1985.

Trade in high technology will almost certainly assume greater strategic importance in the future. In particular, high-technology industries and products are likely to raise security concerns in many countries because of their close relationship with military capabilities. For example:

- Some critical US military applications—including advanced semiconductor and special-purpose manufacturing technologies—rely extensively on imported components. Shifting trade patterns for these technologies could increase US dependence on foreign capabilities in the design of future weapon systems.

- West European arms sales are supported by strengths in aerospace technology, such as British engines and French avionics, which depend largely on export markets for their viability.

- Japan's growing export strength in several areas of high-technology industry is significantly augmenting Japanese capabilities in areas that have many uses in military as well as commercial applications.

Because of these developments and trends, increasing numbers of countries—both industrialized and developing—may conclude that a positive trade balance in certain areas of high technology is important for their longer term interests. If so, world markets will be more sharply contested and international trade frictions could intensify as other countries take active steps to shelter local high-technology producers from import competition or to promote their exports. 25X1

Implications for the United States. The evolving patterns of trade in high-technology industries have substantially different implications for US policy than trade patterns of non-high-technology manufactures. In basic industries such as textiles and steel, trade balances and import-penetration ratios provide a reasonably accurate picture of a country's international competitive position. Most analyses of high-technology trade have not dealt with internationalization of production, however, and by focusing exclusively on 25X1
trade among the industrialized countries, they have failed to capture the large and growing role of developing countries as offshore "assembly platforms"—and even as competitors in their own right—in certain high-technology industries. Moreover, with growing internationalization of high-technology trade, equating export success with technological capability can be misleading. For example:

- An increasing share of trade in some high-technology products, such as West Germany's in aerospace, may actually reflect production of a limited set of components through participation in multinational consortiums, rather than success in the design and production of a complete line of equipment or systems.

- In contrast, an eroding trade surplus, such as that of the United States in computers, may represent an increasing amount of trade generated by US firms' offshore facilities as production is spread across a number of countries, while the US firms continue to be the industry's technological leaders.

Given these differences, approaches to trade policy and negotiations that are oriented toward traditional manufactures could promote outcomes in the high-technology sector that are contrary to the interests of the United States. 25X1

The internationalization of high-technology production has added an important dimension to the US economic position, and is likely to have both positive and negative repercussions for the United States. On the one hand, global diversification is increasing the efficiency and flexibility of individual firms based in or affiliated with the United States, allowing them to reduce production costs and improve access to some foreign markets by operating from offshore locations. At the same time, it is increasing the overall US "trade exposure," or dependence on foreign sources and markets as measured by relative import and export levels. Notwithstanding the commanding position still held by the United States in high-technology trade overall, we conclude that internationalized production in these industries could be increasingly costly to US economic and security interests. Such risks will have to be weighed against any efficiency gains or marketing advantages accruing in the internationalization process to individual US-affiliated corporations.

In three areas in particular, the evolving global pattern of high-technology trade can be expected to have adverse implications for US policy:

- *Conventional trade measures intended to preserve domestic operations in high-technology manufacturing may be ineffective or even counterproductive,* since most high-technology industries are already extensively globalized. Thus, if trade remedies such as antidumping or countervailing duties are applied in one area (such as microelectronics imports), US interests in other areas of high-technology trade (such as computer exports) could ultimately be harmed. Voluntary export restraints are likely to become less workable as the interests of foreign companies—many of which are also increasingly multinational in character—begin to diverge from those of their home-country governments.

- *US initiatives in promoting a new round of multilateral trade negotiations and in managing the international trading system could be undermined* as the nationality of many high-technology products becomes less clear. GATT disciplines and dispute-settlement procedures, which have always been implemented on a country-to-country basis in the past, will be more difficult to enforce in such an environment. Because of the growing importance of trade in parts and subassemblies, as well as expanding offshore assembly and production-sharing consortiums in high-technology industries, traditional negotiating approaches—such as balancing concessions among "principal suppliers"—may not be workable in future trade talks involving these products.

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Appendix A

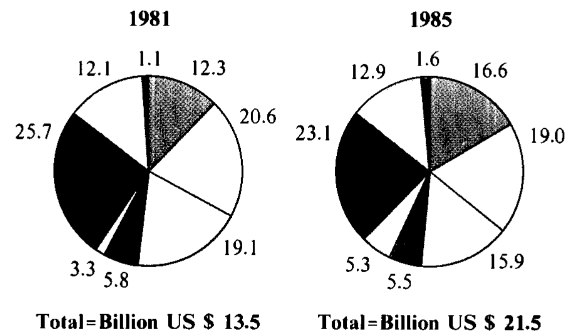
Shares of Global Exports and Trade Balances in Five High-Technology Industries, 1981-85

Figure 14
World Trade in Microelectronics, 1981-85

Note scale change

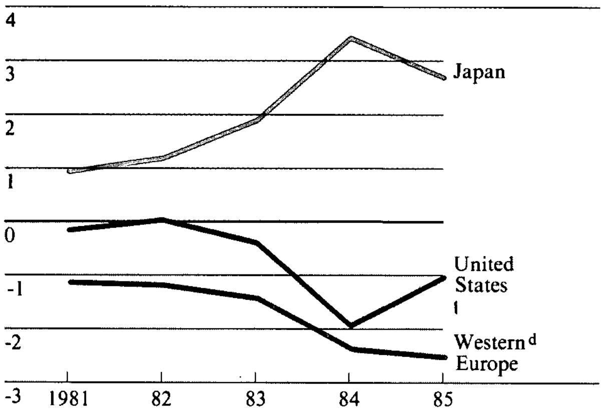
Shares of World Microelectronics Exports[a]
Percent

- Japan
- NICs[b]
- Southeast Asian LDCs[c]
- West Germany
- UK
- US
- Other developed
- Other developing



Trade Balances in Microelectronics
Billion US $

- Surplus
- Deficit



[a] Communist Bloc countries accounted for 0.1 percent of total in 1981 and 1985.
[b] Newly industrialized countries (NICs) include South Korea, Taiwan, Hong Kong, Singapore, Brazil, and Mexico.
[c] Malaysia, Indonesia, Thailand, and the Philippines.
[d] Excludes intra-European trade.

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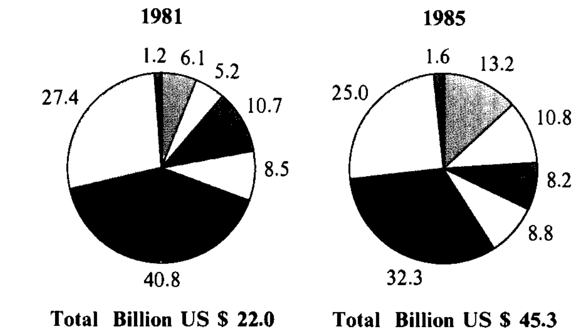
Figure 15
World Trade in Computers, 1981-85

Note scale change

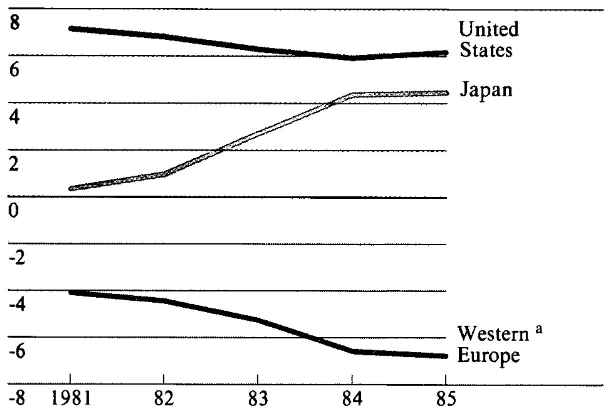
Shares of World Computer Exports[a]
Percent

- Japan
- NICs
- West Germany
- UK
- US
- Other developed
- Other developing



Trade Balances in Computers
Billion US $

- Surplus
- Deficit



[a] Communist Bloc countries accounted for0.1 percent of total in 1981 and 1985.
[b] Newly industrialized countries (NICs) include South Korea, Taiwan, Hong Kong, Singapore, Brazil, and Mexico.
[d] Excludes intra-European trade.

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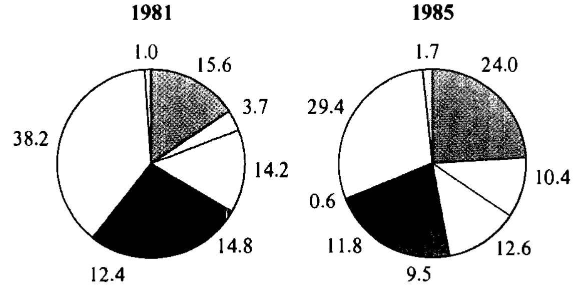
Figure 16
World Trade in Telecommunications Equipment, 1981-85

Note scale change

Shares of World Telecommunications Equipment Exports[a]

Percent

- Japan
- NICs[b]
- Sweden
- West Germany
- US
- Communist Bloc
- Other developed
- Other developing

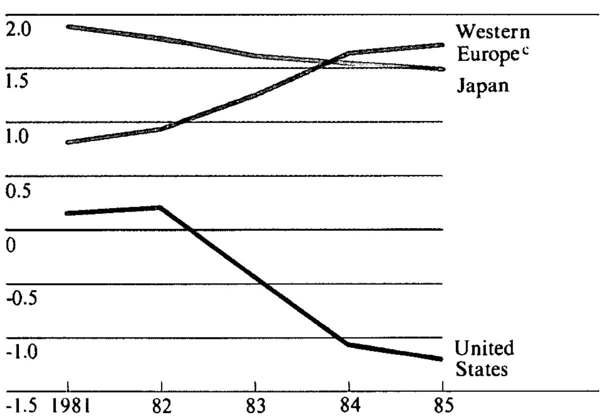


Total Billion US $ 5.5 **Total Billion US $ 7.7**

Trade Balances in Telecommunications Equipment

Billion US $

- Surplus
- Deficit



[a] Communist Bloc countries accounted for 0.1 percent of total in 1981.
[b] Newly industrialized countries (NICs) include South Korea, Taiwan, Hong Kong, Singapore, Brazil, and Mexico.
[c] Excludes intra-European trade.

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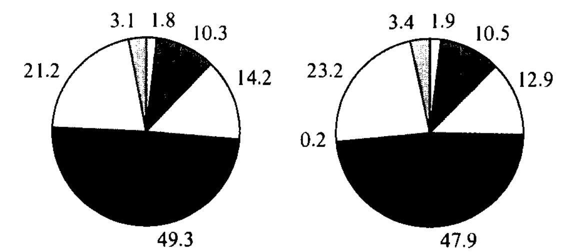
Figure 17
World Trade in Aerospace, 1981-85

Note scale change

Shares of World Aerospace Exports[a]

Percent

- NICs[b]
- West Germany
- UK
- US
- Communist Bloc
- Other developed
- Other developing

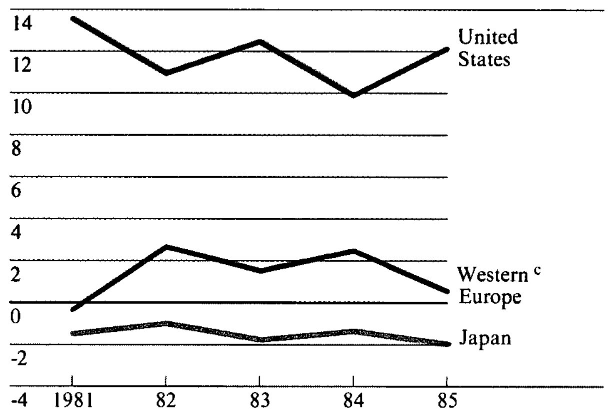


Total=Billion US $ 36.4 **Total=Billion US $ 38.0**

Trade Balances in Aerospace

Billion US $

- Surplus
- Deficit



[a] Communist Bloc countries accounted for 0.1 percent of total in 1981.
[b] Newly industrialized countries (NICs) include South Korea, Taiwan, Hong Kong, Singapore, Brazil, and Mexico.
[c] Excludes intra-European trade.

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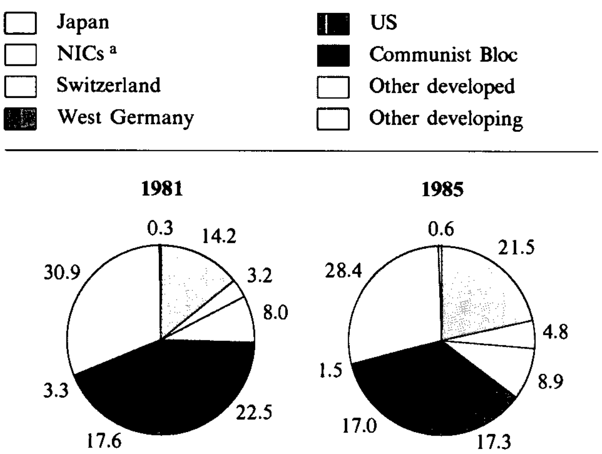
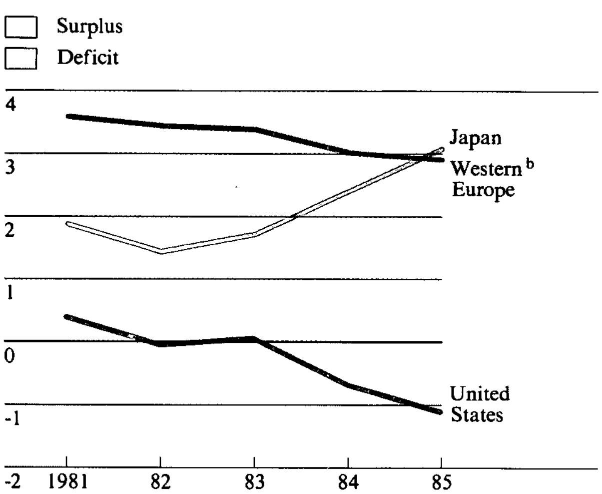
Figure 18
World Trade in Machine Tools and Robotics, 1981-85

Shares of World Machine Tools/Robotics Exports
Percent



Total=Billion US $ 16.6 **Total=Billion US $ 16.6**

Trade Balances in Machine Tools/Robotics
Billion US $



[a] Newly industrialized countries (NICs) include South Korea. Taiwan, Hong Kong, Singapore, Brazil, and Mexico.
[b] Excludes intra-European trade.

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Appendix B

Selected Trade Flows and Other International Linkages Among High-Technology Firms

Figure 19
Selected Trade Flows and Other Linkages Among US, Japanese, and West European Computer Firms, 1980-85

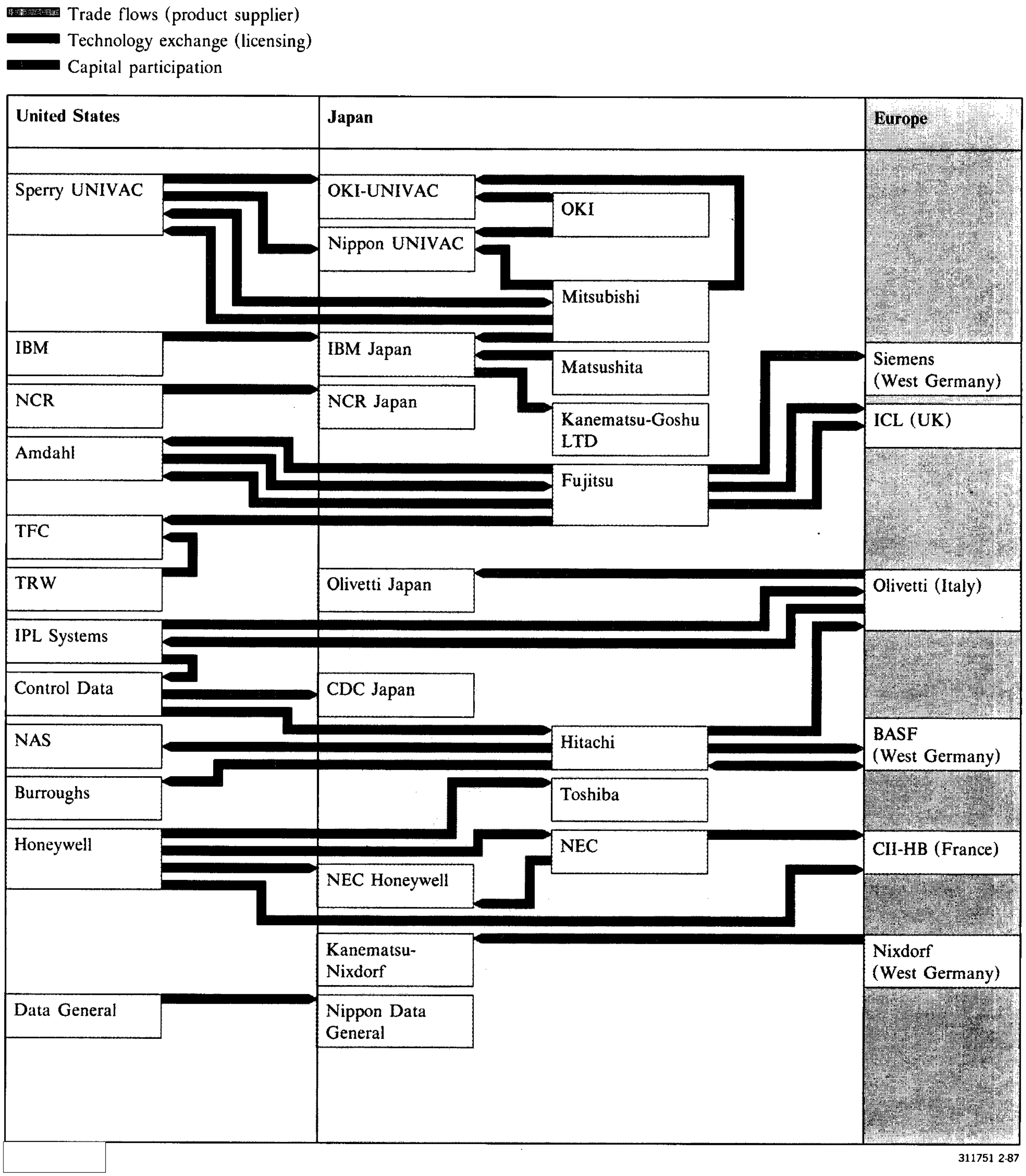

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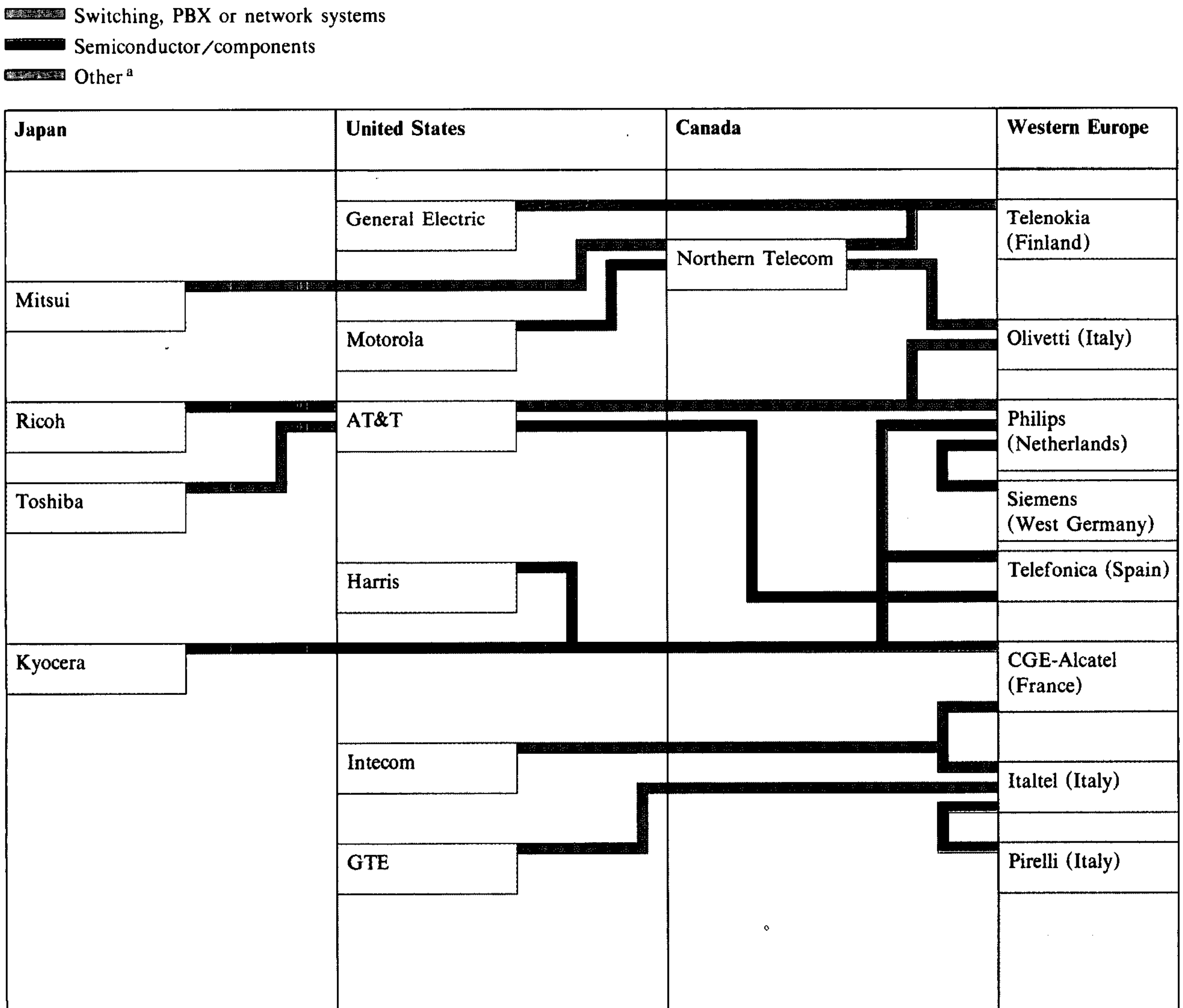
Figure 20
Selected Linkages Among North American, Japanese, and West European Telecommunications Equipment Firms, 1980-86



[a]Other ventures in telecommunications equipment include optical fiber development, data communications equipment production, and radiotelephone equipment production.

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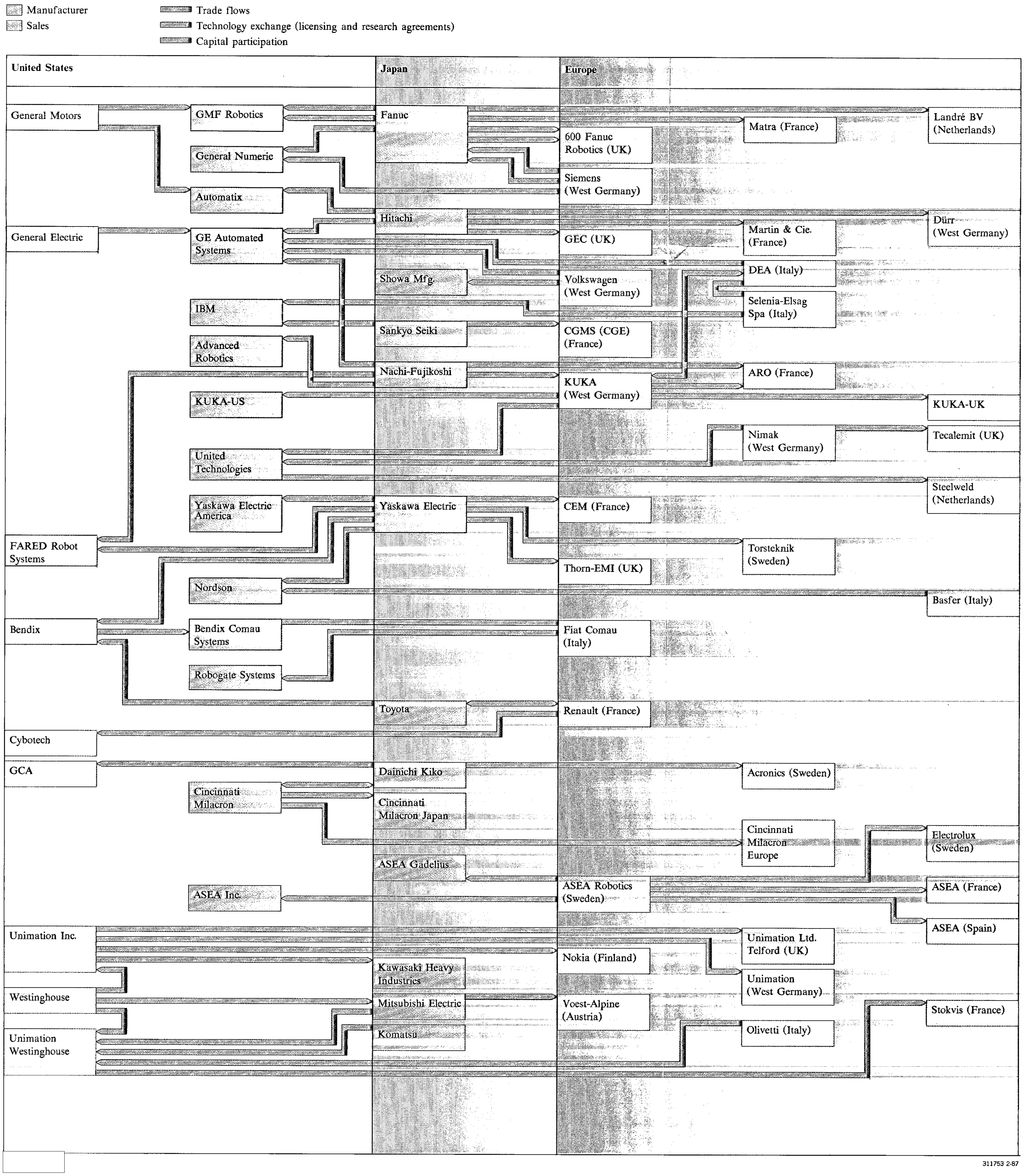
Figure 21
Selected Trade Flows and Other Linkages Among US, Japanese, and West European Robotics Firms, 1983



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